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Der Präsident des Europäischen Patentamts;  
Im Auftrag

For the President of the European Patent Office

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## Image-sensing display device

(86)

The invention relates to an image-sensing display device comprising:

- an image display part including a display panel and lighting means for illuminating the panel, and
  - an image-sensing part arranged on top of the display panel and including a
- 5 two-dimensional array of photosensitive elements.

The invention also relates to a video communication apparatus in general and to a videophone apparatus, for example a mobile phone apparatus, in particular.

10 A videophone apparatus is a telecommunication apparatus that allows users at different sites to talk to each other, but also to view each other faces. Such apparatus should comprise a loudspeaker, a display, a microphone and a camera. In older embodiments of a cord videophone apparatus the display is a cathode ray tube (CRT) display and the camera is mounted at a central position above the CRT. The size of such an embodiment is mainly

15 determined by the size of the CRT. In modern embodiments of the videophone apparatus the display is constituted by a flat display panel, for example a LCD panel. The picture displayed by this panel can be projected on the backside of a projection screen, the front side of which is observed by the user. The camera is arranged behind the projection screen and this screen can be switched between a fully transparent state, wherein the camera takes a picture, and a

20 diffuse state, wherein the picture from the display panel is displayed to the user. This apparatus provides a relative large image which can be viewed at larger distance.

Modern cordless and cellular, or mobile, phone apparatuses comprise a small and direct-view LCD (liquid crystal display) panel for displaying phone numbers, time and other data. Liquid crystals are a kind of materials well suited for use as tiny optical switches

25 to turn picture elements (pixels) on and off. Applying a voltage across this material changes the alignment and light polarising properties of its elongated molecules, so that they can be used in conjunction with polarisation filters to implement an electronic shutter. With a two-dimensional array of such pixels an image can be displayed.

Such an apparatus can be constructed as a videophone apparatus, provided that the camera functions: forming an image of the object and converting this image into an electrical signal, can be combined with, or built in the apparatus.

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US-A 5,340,978 relates to a camera including a solid state sensor and  
5 describes various arrangements for employing optical elements in association with the  
photosensitive elements of the image sensor. Also described is an image-sensing display  
panel comprising an LCD panel, a substrate having an array of photosensitive elements  
disposed on its surface and an optically transparent layer arranged above the array and  
capable of focussing light onto said array. Various embodiments of this image-sensing  
10 display panel are shown, which embodiments differs from each other by the mutual  
arrangement of the LCD panel, the array of photosensitive elements and the transparent layer.  
In each of these embodiments the LCD panel is a transmission panel and the lighting means  
are back lighting means.

15

It is an object of the present invention to provide an improved image-sensing  
display device of the kind defined in the preamble for use in a mobile videophone apparatus  
and for other applications. This device is characterised in that the display panel is a reflective  
panel and in that the lighting means are front lighting means and arranged in front of the  
20 array of photosensitive elements.

A mobile or cordless videophone system is to be used in daylight  
circumstances and should display a bright image. By using a reflective display panel a bright  
image can be obtained with a relative low lighting intensity and a corresponding relative low  
electrical power consumption, which is also of large importance for a mobile or cordless  
25 videophone. Moreover, as the front lighting means are arranged in front of the array of the  
photosensitive elements, imaging elements of the camera can be accommodated in these  
lighting means.

In the present specification a cordless videophone apparatus is understood to  
be a videophone apparatus which receives and transmits sound and vision signals via a  
30 receiver and transmitter device in the neighbourhood and connected to a cable network. A  
mobile videophone apparatus is a videophone apparatus which travels with the user and  
receives and transmits sound and vision signals through the air from a local transmitter,  
which may be positioned at a larger distance.



A first embodiment of the image-sensing display device, wherein the display panel comprises a transparent front plate, is characterised in that the array of photosensitive elements is arranged under the front plate.

5 A second embodiment of the image-sensing display device, wherein the display panel comprises a transparent front plate, is characterised in that the array of photosensitive elements is arranged on the front plate

The camera lens means for imaging an object or scene on the array of photosensitive elements may be a single lens element arranged in front of the image-sensing display device. A preferred embodiment of the image-sensing display device, wherein the  
10 lighting means comprises a front light guide, is however characterised in that lens means are integrated in the light guide.

By using the front light guide as a carrier for lens means a high degree of integration becomes possible and a compact construction is obtained.

A front light guide is understood to be a flat plate of transparent material  
15 arranged at the front side of the image-sensing display device and wherein light from a source, for example one or more LED's, is coupled in via one or more side faces and, after one or more reflections at the flat main faces, is sent to the LCD panel.

A further preferred embodiment of the image-sensing display device is characterised in that lens means are arranged on the front plate of the LCD panel.

20 The latter lens means may replace the lens means integrated in the light guide or may be combined with them. In the latter case an improved image may be formed on the array of photosensitive elements.

The image-sensing display device may be further characterised in that the array of photosensitive elements is constituted by a CCD sensor.

25 CCD (charge coupled device) sensors have matured in reliable and high resolution sensors which are very suitable for the device of the present invention.

Alternatively the image-sensing display device may be characterised in that the array of photosensitive elements is constituted by a C-MOS image sensor.

A C-MOS image sensor, which shows the advantages that it can be integrated  
30 with other circuitry on a single chip and has reduced packaging costs, is an attractive image sensor for the device of the present invention.

The image-sensing display device may be further characterised in the display panel is a LCD panel.

LCD panels which are widely used as high-resolution, full-colour displays and are very suitable as display panels in the devices of the present invention.

Preferably the image-sensing display device is further characterised in that the material of the LCD panel is a cholesteric liquid crystal.

5 A cholesteric liquid crystal has a periodic structure with a periodicity that matches a given, visible, wavelength. It can be switched between a first state, wherein light with said given wavelength is reflected, and a second, transparent, state. A cholesteric liquid crystal display consumes power only when its information content is changed and allows lower power consumption of an LCD that displays relative stable information. Such a display  
10 is therefor very well suitable for a mobile videophone apparatus.

The invention also relates to an image communication apparatus comprising image display means, including an image display panel, and camera means, including an image sensor. This apparatus is characterised in that the image display panel and the image sensor are constituted by the image-sensing display device as described above.

15 Examples of such an image communication apparatus are an adapted flat monitor of a desktop computer or of a notebook computer.

The invention further relates to a videophone apparatus comprising a voice communication part and an image communication part, wherein the image communication part comprises image display means, including an image display panel, and camera means,  
20 including an image sensor. This apparatus is characterised in that the image display panel and the image sensor are constituted by the image-sensing display device as described above.

The advantages of the invention are prominent for a videophone apparatus which is constructed as a mobile apparatus.

25

These and other aspects of the invention are apparent from and will be elucidated with reference to the embodiments described hereinafter. In the drawings:

Fig.1 shows a mobile videophone apparatus wherein the image-sensing display device of the present invention can be implemented;

30 Fig. 2 shows a block diagram of the functions of this apparatus;

Fig. 3 shows an embodiment of the image-sensing display device of the present invention;

Fig. 4 shows a principle diagram of a transmission LCD panel;

Fig. 5 shows a principle diagram of a reflective LCD panel;

Fig. 6 shows an embodiment of the lighting means to be used with a reflective LCD panel;

Figures 7a and 7b show two embodiments of the image-sensing display device of the present invention;

Fig. 8 shows such a device with a planar lens structure at the upper surface of the light guide;

Fig. 9 shows a top view of a Fresnel lens;

Fig. 10 shows an image-sensing display device with a planar lens structure at the lower surface of the light guide;

Fig. 11 shows an image-sensing display device with two planar lens structures and a micro lens structure;

Fig. 12 shows an image sensor with a micro lens structure;

Fig. 13 shows a cordless videophone apparatus provided with an image-sensing display device;

Fig. 14 shows a notebook provided with an image-sensing display device, and

Fig. 15 shows a desk top computer provided with an image-sensing display device.

Figure 1 is a perspective view of a mobile, or cellular, telephone apparatus 1, the front surface of which is provided with a key entry section 3. This section comprises a number of button switches 4, for dial entry and other functions. A display device 10 is disposed above the section 3 and an antenna 5 is provided on the upper surface of the phone 1. When a dial, such as a ten-key dial, is entered from the button switches 4, information relating to the entered dial is transmitted to a base station of a telephone company from the antenna 5 via a transmitting circuit 7 in the phone 1, as illustrated in Fig.2.

This Figure shows a block diagram of the functions of the telephone. The information relating to the entered dial is sent to a display driving circuit 9 which drives the display device 10 such that this device displays the dial information.

If a conventional mobile telephone apparatus is provided with camera means and its circuitry is adapted, its capabilities are considerably increased. The mobile apparatus can be used then as a videophone apparatus. The original videophone apparatus, which is a cord apparatus, is intended as an extended telephone apparatus which makes not only the

voices of two remote users audible, but also the faces of these users visible, to each other.

This apparatus can also be used to make graphics and other data at the site of one user visible to the other user. It has also already been proposed to use a mobile videophone apparatus for displaying moving, or real video, images and for accessing world-wide electronic

5 information networks, like the Internet. To that end at least the image sensor of the camera means should be incorporated in the mobile videophone apparatus, which means that the display device 10, should be an image-sensing display device instead of a display device only, like an LCD panel.

Fig.3 is an exploded perspective view and shows the components of an image-  
10 sensing display device 20 according to the present invention. This device comprises, from the base, successively a display panel 30, an image sensor 40, for example a CCD sensor, a surface lighting means 50 and lens means 60, schematically represented as a curved lens element. The components are juxtaposed in the Z direction, i.e. the viewing direction of a user, and the components 30,40 and 50 may be integrated by a case 65. The Z-dimensions of  
15 the components, relative to their X- and Y-dimensions are much smaller than indicated in Fig.3

Fig. 4 shows a diagram of a conventional transmission liquid crystal display panel 70. This panel comprises a layer of liquid crystalline material 71, for example, of the nematic type which is enclosed between two transparent plates 72 and 73, for example of  
20 glass. Drive electrodes 75 and 76 are arranged on each plate. At least the electrode 76 is divided into a large number of rows and columns so that a large number of picture elements, or pixels, in the display panel is defined. The different pixels are driven by driving the matrix electrodes, as is shown schematically by means of the drive terminals 77 and 78. Thus an electric field can be applied across the liquid crystalline material 71 at the required positions,  
25 i.e. the pixel positions. Such an electric field causes a change of the effective refractive index of the material 71, i.e. a change in the alignment and light polarising properties of its elongated molecules so that the light passing through a given pixel undergoes, or does not undergo, a rotation of the direction of polarisation depending on the absence, or presence, of a local electric field at the location of the relevant pixel. By means of a polarising filter 79  
30 arranged between the electrode 75 and the viewer eyes, the polarisation change is converted into an intensity change so that the pixel becomes visible or non-visible to the viewer. The combination of visible and non-visible pixels forms an image which can be changed rapidly, for example 25 or 50 times per second. A display panel wherein the pixels are formed by the

intersection of, and are directly driven by the voltage between, the row and column electrodes is termed a passive-matrix display.

Instead of a passive-matrix display panel, an active-matrix LCD (AMLCD) panel may be used. In this display panel the drive electronics is constituted by an array of silicon transistors, which are arranged on the plate 73. Each pixel is now driven by its own transistor, preferably an thin film transistor (TFT). Both types of display panels are described in, for example, EP-A 0.266.184. Active-matrix displays are able to show colour images of superb quality and high resolution and are developing to devices which can show more and more complex information. Passive-matrix displays are easier to manufacture and consume relative low power. These displays are suitable for applications where the demands with respect to brightness, number of pixels and response time are moderate.

LCD panels are not emissive: they do not generate light themselves. Instead direct view transmission LCD panels are provided with back lighting means, comprising a light source and a planar light guide 80 shown in Fig. 4.

In the image-sensing display device of the present invention a reflective display panel is used, instead of a transmission panel. The combination of a reflective display panel and an image sensor is not only new, but provides important advantages especially, but not only, for cordless apparatus. These advantages relates to an efficient use of light, and thus of power of the battery which supplies electric power to the lighting means, and also to constructional aspects of the apparatus.

A reflective LCD panel may use ambient light, so that when it is used in a bright or daylight environment no additional lighting of the panel is needed. The contrast in the displayed image increases with increasing intensity of the ambient light, because the intensity of the image forming reflected light then also increases, while the degree of blackness of the black pixels does not change. If a transmission LCD panel is used in an environment with increasing ambient light the contrast of the displayed image will decrease. Then the intensity of the back lighting should be increased to obtain an image with sufficient contrast. This means that the back lighting means would consume more electric power which is disadvantageously, especially for a cordless apparatus which is powered by a battery.

Fig.5 shows a diagram of an embodiment of a reflective LCD panel 30 that may be used in the image-sensing display device of Fig.3. This panel comprises a liquid crystalline layer 31, similar tot the layer 71 in Fig.4. The layer 31 is sandwiched between a transparent plate 32 similar to plate 72 in Fig.4 and a second plate 33. The plate 32 is provided with one counter electrode and the plate 33 carries an array of driving transistors,

one for each of the pixels, which driving array is schematically indicated by the layer 35. The front side 36 of the plate 33 is reflective. The reflective panel functions in the same way as the transmission panel of Fig.4, with the exception that the image forming light is reflected and not transmitted.

5 In the transmission LCD panel, shown in Fig.4, the effective area of the pixels that is available for polarisation modulation of the light is limited by the areas occupied by the drive means for the pixels, i.e. the row and column electrodes for a passive-matrix display or the driving transistors in an active-matrix display. The presence of these portions puts a limit to the resolution of the display panel, i.e. the number of pixels per surface unit area.

10 Since light incident on such area portions, thus outside the effective areas of a pixels, is absorbed and not used for image formation, the said portions put also a limit to the light efficiency of the display, i.e. the ratio of the amount of light used for image formation and the amount of light incident on the display panel, and thus to the brightness of the displayed image. The brightness could be improved by increasing the intensity of the light incident on  
15 the panel, which implies more battery power consumption, or by adding to the panel lens means, such as a micro lens array to concentrate the available light on the effective areas of the pixels, which complicates the structure of the device.

However, the above limits do not occur in a reflective active-matrix panel of Fig.5, wherein the driving transistors are arranged under the liquid crystalline layer 31 and do  
20 not cover portions of this layer. Now, substantially the whole surface area of the liquid crystalline layer can be occupied by effective areas of the pixels and the resolution of the panel is larger than that of a transmission panel and of a reflective passive-matrix panel. Moreover, substantially all of the light incident on the panel is reflected and modulated and used for display of the image. Whereas in general a reflective LCD panel has a higher light  
25 efficiency than a transmission panel, an active-matrix display reflective panel shows the further advantages of higher resolution and excellent image quality. Incorporating an image-sensing display device with such a panel in a mobile or cordless telephone apparatus will render this apparatus suitable as a videophone apparatus for displaying high quality data, graphics and video images and for accessing, for example, the world-wide Internet or other  
30 communication networks.

In practice a reflective LCD panel for the envisaged applications will be provided with lighting means. However, these means may be switched on only when needed, i.e. when the ambient light is too weak. For a transmission LCD panel the back lighting

means should be switched on under all use circumstances, so that a reflective panel is more efficient with respect to electric power consumption than a transmission panel.

The lighting means for the reflective panel used in the image-sensing display device is a front lighting means, which comprises a flat light guide arranged in front of the image sensor. This construction provides the possibility to integrate camera lens elements in the front light guide or in the image-sensing display device. it will be clear that the light source of the lighting means is switched only in the display mode of the device and not in the camera mode.

The front lighting means has two main flat surfaces behind each other in the viewing direction, i.e. the Z-direction of Fig.2., so that one of these, or both, surfaces can be provided with a lens structure.

Fig.6, which shows a cross-section of an embodiment of the front lighting means 50, illustrates the principle of this means. The front lighting means comprises a transparent light guiding plate 81, for example of glass or transparent plastics. Fig.6 shows only a portion of this plate. The plate 81 has a lower main flat surface 85, facing the image sensor (not shown in Fig.6), an upper main flat surface 86 and four side surfaces, only one of which, 88, is shown in Fig.6. At least one light source 90 is arranged opposite to at least one of the side surfaces. The plate is provided with a number of scattering elements 93. Light rays 91 from the source 90 enter the plate 81 via the side surface 88 and are total internally reflected one, two or more times, dependent on the direction of a ray, before they reach a scattering element 93. Such an element reflects light incident thereon in different directions. A portion of the reflected light, indicated by the rays 95, has such a direction that it passes through the lower main surface 85 of the plate and propagates to the LCD panel 30. The rest of the reflected light propagates further in the plate 81 until it reaches a further scattering element 94. A portion of the light reflected by this element passes through the lower surface 85 of the plate 81 and the rest propagates further through the plate. This goes on until substantially all the light that entered the plate via the side surface 88 is coupled out of the plate and is directed towards the LCD panel 30. This process will be enhanced if the side face of the plate opposite the entrance face is made reflective. A reflector, indicated by the broken line 98, may be arranged around the light source 90 to increase the amount of source light that enters the plate. For example, the light source may be arranged in a parabolic reflector, which is placed against the entrance side face of the plate.

For back lighting means, i.e. means for illuminating the back side of a transmission panel, various embodiments are known, for example from US-A 5,816,677 and

EP-A 0.881.426. Features known for back lighting means can also be used in front lighting means. For example, the light source may be a light tube arranged at one side face of the light guide plate, or two or more of such tubes may be arranged at different side faces of the plate. It is also possible to use a bent tube that surrounds the plate. Such tubes for a back light  
5 are described in US-A 5,619,351. For a small image-sensing display device the light source is preferably a light emitting diode, or LED. Bright and small-sized LED's with low power consumption and a long life time are now available in different colours. For a colour image-sensing display device one or more sets of three LED's emitting the primary colours red, green and blue may be used. Fig.3 shows one such a set of three LED's 52,53 and 54.

10               The scattering elements 91,94 etc. may be constituted by portions of spheres, by blocks or by flat elements. If light sources are arranged at opposite side surfaces of the light guide plate 50, these scattering elements may be distributed uniformly over the flat upper surface 80 of this plate, so that the light leaving the plate via the surface 85 shows the required uniform intensity. If one or more light sources are arranged at only one side face of  
15 the plate 50, the uniform intensity can be obtained by increasing the density of the scattering elements, i.e. the number of such elements per flat surface area unit, from the light incidence face to the opposite face. If the light enters the plate 50 via both a YZ face and an XZ face, it can be arranged that both in the X-direction and in the Y-direction the density of the scattering elements increases from the these faces to the opposite faces. A uniform intensity  
20 of the light leaving the plate 50 can also be obtained by adapting the properties of the scattering elements, for example, their dimensions or their scattering power, such that at the position of the light incident face(s) less scattering occurs than at the opposite face(s). Under circumstances it may be preferred that the light illuminating the display panel is not uniformly distributed. Such a required non-uniform illumination can also be obtained by  
25 adapting the density of the scattering elements and/or their scattering properties.

              The image sensor , 40 in Fig.3 is a so-called solid state sensor comprising a two-dimensional array of photosensitive elements on a substrate. The substrate may be a silicon semiconductor substrate. The array of photosensitive elements may be a well-known CCD (charged coupled device, an array of memory cells which discharge upon incidence of  
30 light, a CMOS array or any other suitable device the state of which is changed or which generates a signal or signal difference upon incidence of light. For example, a CMOS image sensor as described in the article: "Design of real-time image enhancement preprocessor for CMOS image sensor" in: IEEE Transactions on Consumer Electronics, Vol 46, No. 1, February 2000, pages 68-75, may be used. The array of photosensitive elements may



comprise hundreds or thousands of rows and columns and may have a square or rectangular shape. The elements may be evenly spaced or the elements of one row, or column, may be offset from the elements of an adjacent row, or column. The image sensing array has sufficient transmission so that an image displayed on the display panel may be seen through  
5 the array.

The image sensing array 40 may be arranged on the LCD panel, i.e. on the front glass of this panel. It is, however, also possible to arrange the image sensing array at the underside of the front glass. These embodiments are schematically illustrated in Figures 7a and 7b, respectively, wherein the front glass is indicated by the reference number 100.

10 The image-sensing display device should be provided with lens means to image a subject or scene or computer data (graphics) on the image sensing array. Such lens could be a separate lens element 60 mounted in front of the device, as shown in Fig. 4. However, the construction of the device enables integration of the required lens means and to add further lens means without substantially enlarging or complicating the device. As shown  
15 in Fig.8, a planar objective lens 110 may be provided on the top surface of the light guide 50 in the embodiment of Fig.7a. Such a lens, the working of which is based on diffraction instead of on refraction, may be a Fresnel lens. Fig.9 shows a top view of such a Fresnel lens. The lens structure is constituted by a transparent central circular portion 112 and a large number of alternating non-transparent and transparent rings 115 and 113, respectively, the  
20 width and mutual spacing of which decreases from the centre to the periphery. Instead of this amplitude structure, the Fresnel lens may have a phase structure. The latter structure consists of rings which introduce alternately a first phase shift, for example  $0^\circ$ , and a second phase shift, for example  $180^\circ$ , in the beam portion passing through them. The beam portions from the different rings constructively interfere with each other in the focal plane of the Fresnel  
25 lens, so that the total result is comparable with that of a refractive lens. For clearness sake, in Figures 8 and 9 only a few of the rings are shown; in practice the number of rings is much larger. The planar lens 110 may also be arranged at the lower surface 54 of the light guide 50 or at the upper surface 42 of the image sensor 40.

As shown in Fig.10, the planar objective lens 110 may also be arranged at the  
30 lower surface 54 of the light guide. It is also possible that the planar lens is arranged at the upper surface 42 of the image sensor 40. Also in the embodiment of Fig.7b a planar objective lens can be arranged on either the upper surface or the lower surface of the light guide 50 or in the front glass 100 of the combined display and image sensing panel.

A second planar lens may be arranged in the image-sensing display devices of Figures 7a and 7b on another surface than the surface which carries the first planar lens. Such a second lens can compensate for the lens aberrations of the first lens.

As the new image-sensing display device comprises three surfaces in front of  
5 the image-sensing array, namely the upper (52) and lower (54) surfaces of the light guide (50) and either the upper surface of the image sensor 40 (Fig.7a) or the front glass 100 (Fig.7b), in principle this device can be provided with three lens structures. One or two of these structures may be a micro lens structure, which can be used to concentrate the incident light on the photosensitive elements of the image sensing array. Fig.11 shows an embodiment  
10 of the image-sensing display device which comprises a first planar lens 110 on the upper surface 52 of the light guide 50, a second planar lens 120 on the lower surface 54 of the light guide and a micro lens structure 130 on the upper surface of the image sensor 40.

Fig.12 shows a perspective view of an embodiment of the micro lens structure 130 on top of the image sensor 40. The photosensitive elements of this sensor are indicated  
15 by the reference numeral 46. The micro lens structure may comprise one lens for each photosensitive element. If the photosensitive elements are arranged in groups of three, which may be the case for a colour camera wherein the three elements of each group are destined to receive light of different colours (red, green or blue) one micro lens may be provided for each group of three elements. The micro lenses 133 may be refractive elements and may be  
20 constituted by spherical indentations in, or spherical bumps on, a thin plate 131. Preferably, the micro lenses are planar diffraction elements which are integrated in the front surface of the image sensor.

The number of lens structures and the kind of lens structures, Fresnel lens or micro lens, and in which of said three surfaces the lens structures are integrated is  
25 determined by the required image quality.

Preferably, the liquid-crystal in the display panel 30 is a so-called cholesteric liquid-crystal. In a transversal cross-section of the cholesteric liquid crystal layer, its molecular structure is a helical structure with a periodicity that matches the wavelength of visible light. The use of such a liquid crystal as a polarisation and colour filter in an LCD  
30 image projector is described in the article: "Novel polarized liquid crystal color projector and new TN-LCD operating modes" presented at the SID conference, 15-17 May, Las Vegas. A cholesteric liquid crystal has the advantage of being stable in two states. In one state the orientation of the molecules belonging to given layer surface domains (pixels) is such that light with a matched wavelength is reflected by these domains. In this state the domains form

microscopic interference filters. In the second state, the liquid crystal has domains that are too small to generate significant interference, resulting in the layer being transparent. With an appropriate series of voltage pulses, the cholesteric liquid crystal layer can be switched between these two states. Because there is a significant energy barrier between these two states, the display exhibits a bistable behaviour: the display retains the image even when the applied voltages are switched off. Cholesteric liquid-crystal displays therefore consume power only when their information content is changed, allowing a lower power consumption of displays that display relatively stable information, such as those in mobile phones. The use of cholesteric liquid-crystal material in displays has the advantage these displays reflect light much more like paper, thereby improving image quality. A cholesteric liquid-crystal display can be made suitable for displaying colour images by stacking three cholesteric layers having different periodicity's which are matched to the red, blue and green wavelength, respectively.

The image-sensing display device of the present invention may be used not only in a mobile videophone apparatus, but also in a cordless videophone apparatus 140 as shown in Fig.13. In this Figure 142 is the base station which is connected to a phone or cable network and 143 is the movable apparatus which can be used within an area of for example less than 100 m from the base station. Apparatus 143 comprises a key section 145 and an image-sensing display device 147 constructed as described herein before. For the mobile and cordless videophone apparatus the compactness, i.e. the depth, of the image-sensing display device and minimum power consumption of this device are important features.

This is also the case for a portable computer, known as notebook, 150 shown in Fig.14. In this Figure, 151 is the base part accommodating the different modules and the key board 153. 155 is the monitor part which conventionally has only a display function. If the monitor is constructed as described herein before, it has also a camera function.

Figure 15 shows a desk top computer 160 comprising a key board 161, a computer box 164 and a monitor.165. The monitor is a flat LCD monitor fixed in a support 166. 167 is a image-sensing display device constructed as described herein before, so that the monitor has in addition to the conventional display function also a camera function.

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## CLAIMS:

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1. An image-sensing display device comprising:  
- an image display part including an image display panel and lighting means for illuminating the panel, and

- an image-sensing part arranged on top of the display panel and including a  
5 two-dimensional array of photosensitive elements, characterised in that the display panel is a reflective panel and in that the lighting means are front lighting means which are arranged in front of the array of photosensitive elements.

2. An image-sensing display device as claimed in claim 1, wherein the display  
10 panel comprises a transparent front plate, characterised in that the array of photosensitive elements is arranged under the front plate.

3. An image-sensing display panel as claimed in claim 1, wherein the display  
15 panel comprises a transparent front plate, characterised in that the array of photosensitive elements is arranged on the front plate.

4. An image-sensing display panel as claimed in claim 1, 2 or 3, wherein the  
lighting means comprise a front light guide, characterised in that lens means are integrated in the light guide.

20 5. An image-sensing display device as claimed in claim 1, 2 or 3, characterised in that lens means are arranged on the front plate of the display panel.

6. An image-sensing display device as claimed in any one of claims 1-5,  
25 characterised in that the array of photosensitive elements is constituted by a CCD sensor.

7. An image-sensing display device as claimed in any one of claims 1-5, characterised in that the array of photosensitive elements is constituted by a C-MOS image sensor.

5 8. An image-sensing display device as claimed in any one of claims 1-7, characterised in that the display panel is a LCD panel.

9. An image-sensing display device as claimed in claim 8, characterised in that the material of the LCD panel is a cholesteric liquid crystal.

10

10. An image communication apparatus comprising image display means, including an image display panel, and camera means, including an image sensor, characterised in that the image display panel and the image sensor are constituted by an image-sensing display device as claimed in any of claims 1-9.

15

11. A videophone apparatus comprising a voice communication part and an image communication part, wherein the image communication part comprises image display means, including an image display panel, and camera means, including an image sensor, characterised in that the image display panel and the image sensor are constituted by an  
20 image-sensing display as claimed in any one of claims 1-9.

12. A videophone apparatus as claimed in claim 11 constructed as a mobile apparatus.

## ABSTRACT:

An image-sensing display panel comprises an image display, including a display panel (30) and lighting means, and an image sensor (40). By using a reflective LCD display panel (30) and arranging the light guide (50) of the lighting means in front of the image sensor (40), the device has a high light efficiency and lens means (110, 120, 130) can  
5 be integrated in components (40, 50, 100) of the device which results in a compact construction of the device.

Fig. 7a

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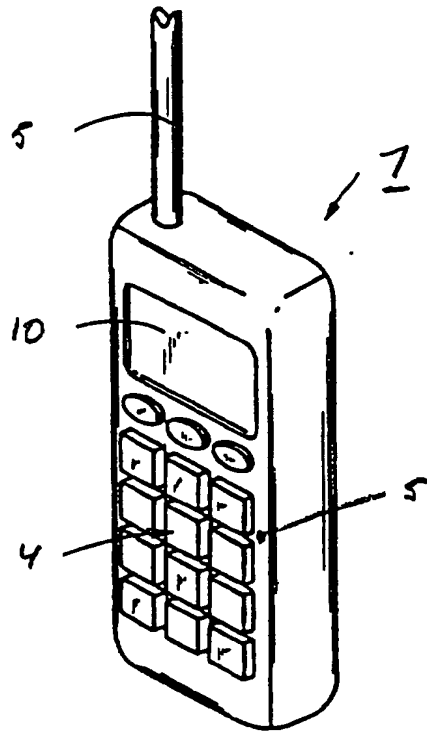


Fig. 1.

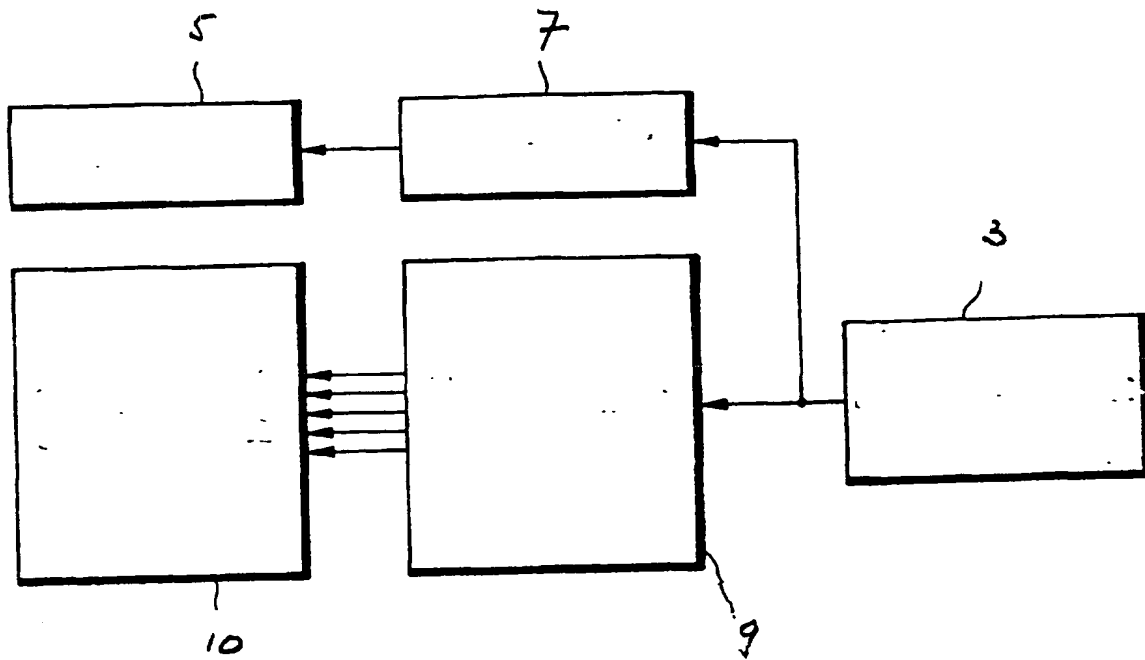
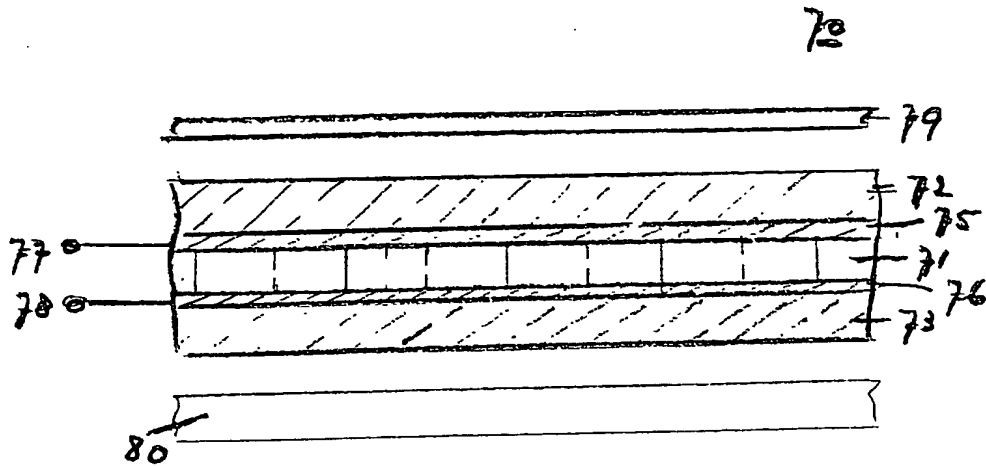
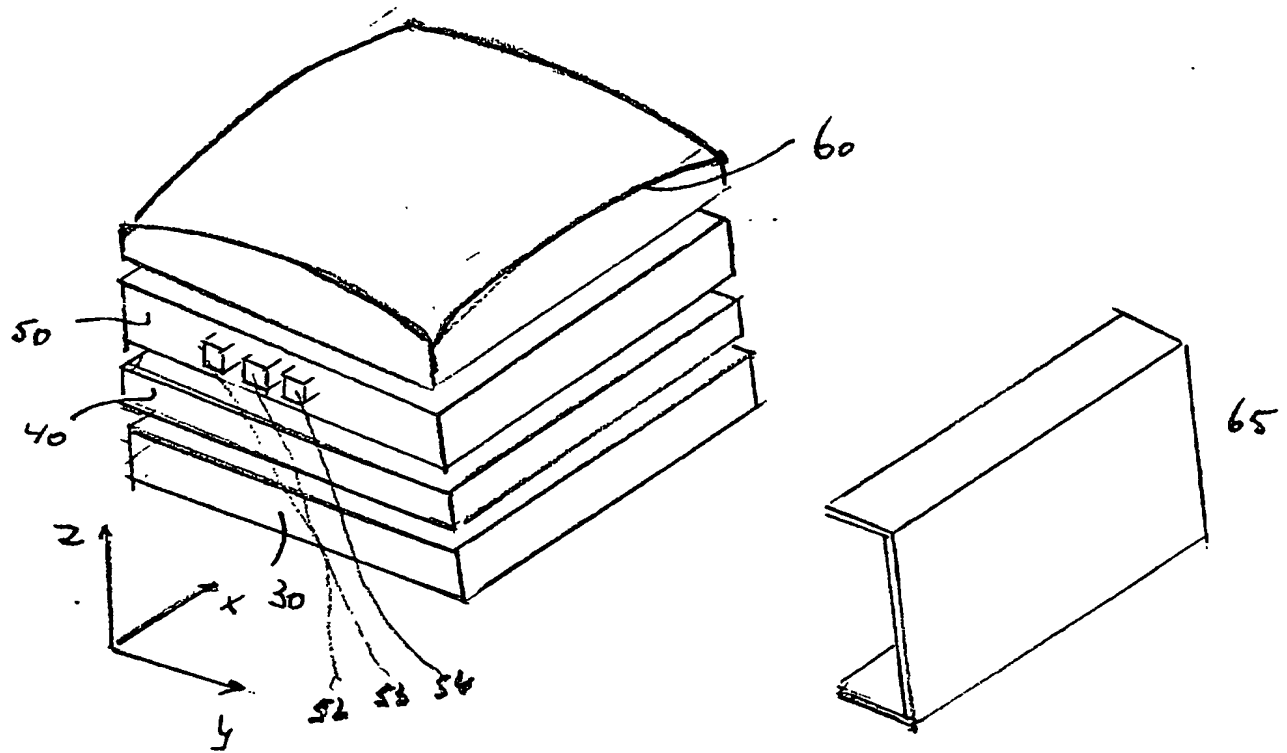


Fig. 2



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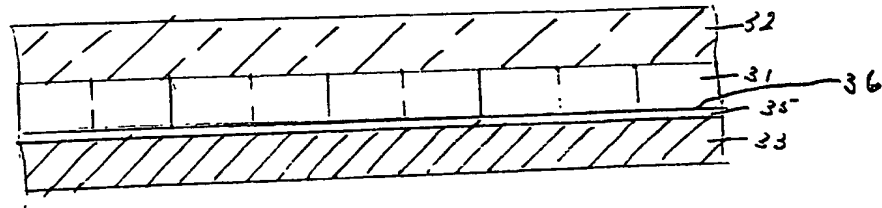


Fig 5

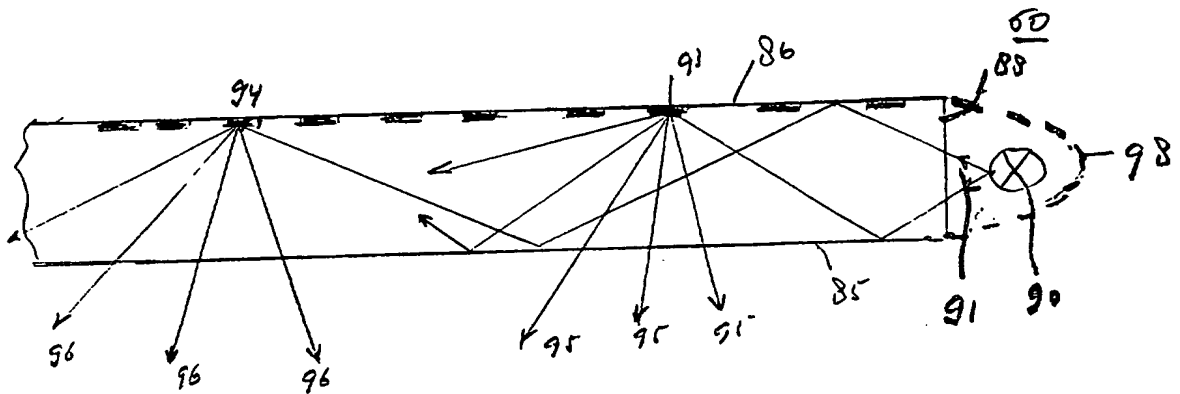


Fig 6

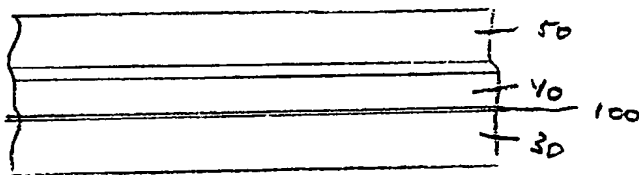


Fig 7a

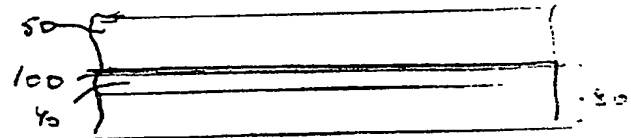


Fig 7b

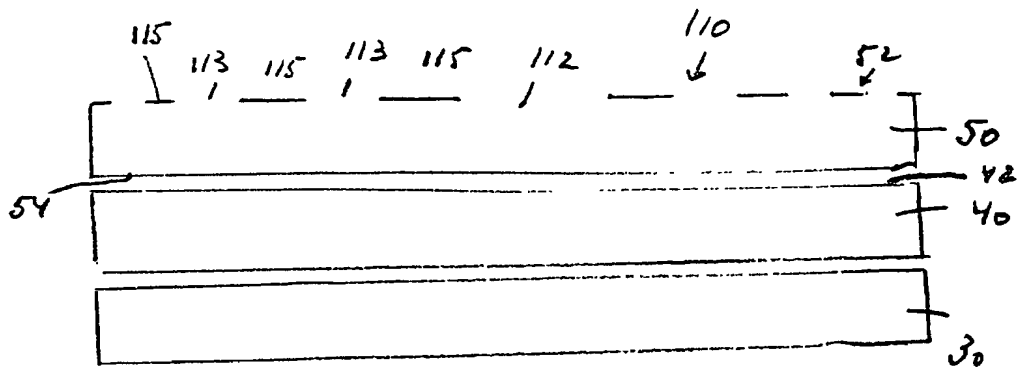


Fig 8

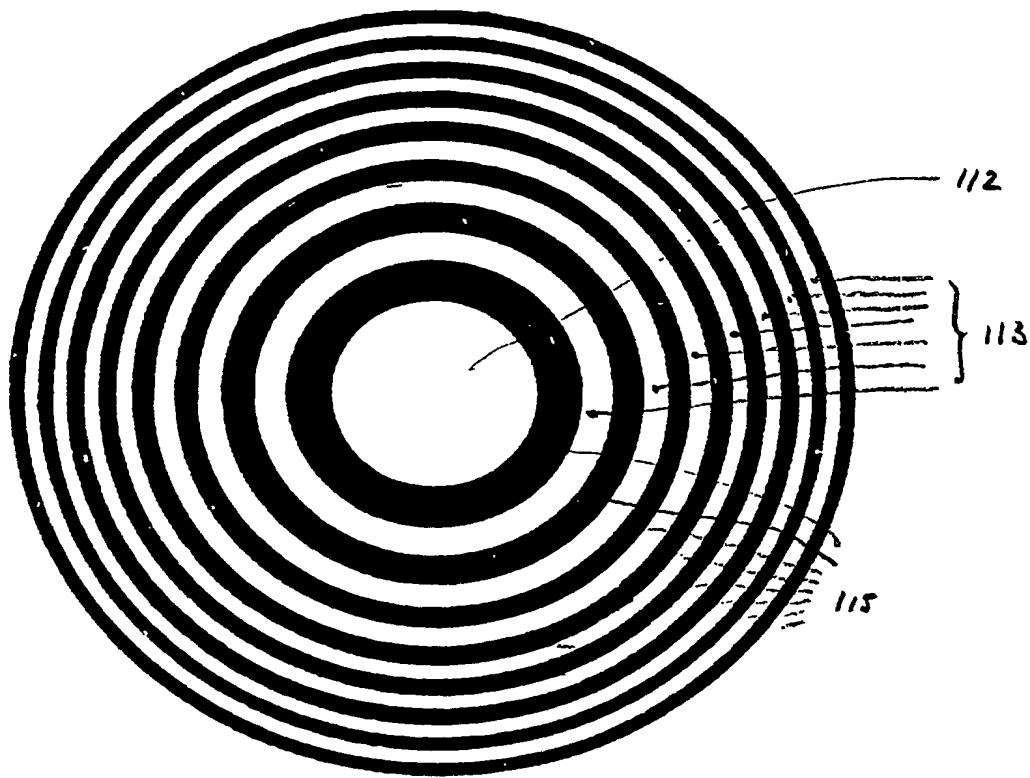


Fig 9

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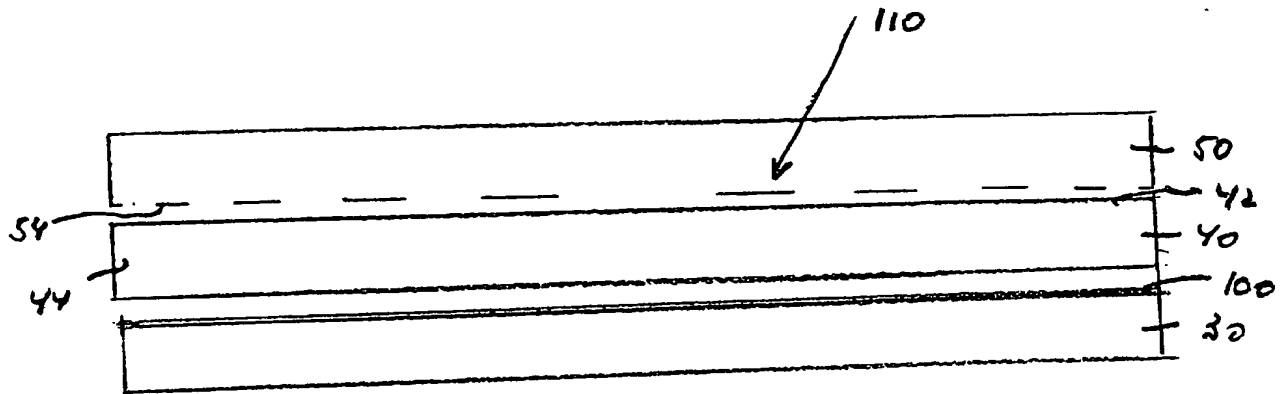


Fig 10

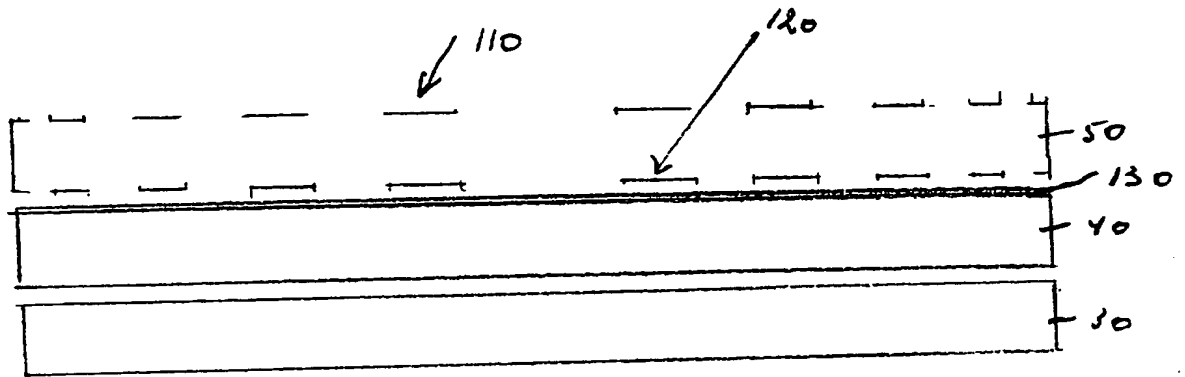


Fig 11-

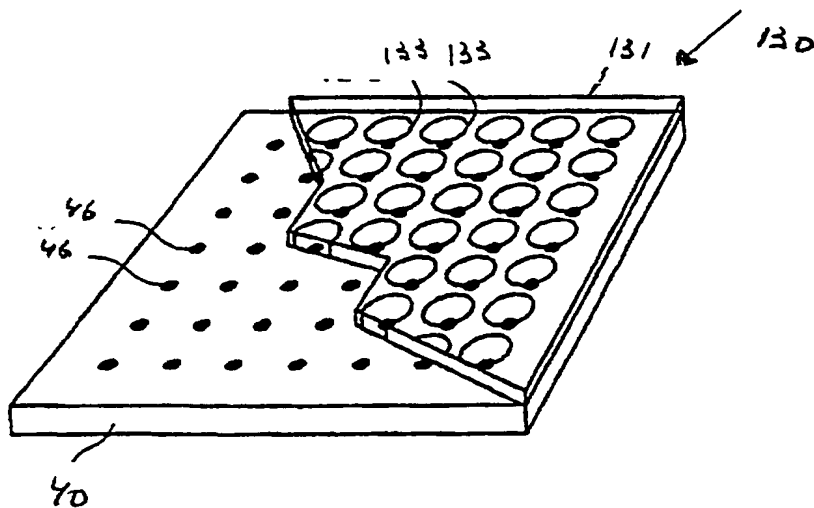


Fig 12

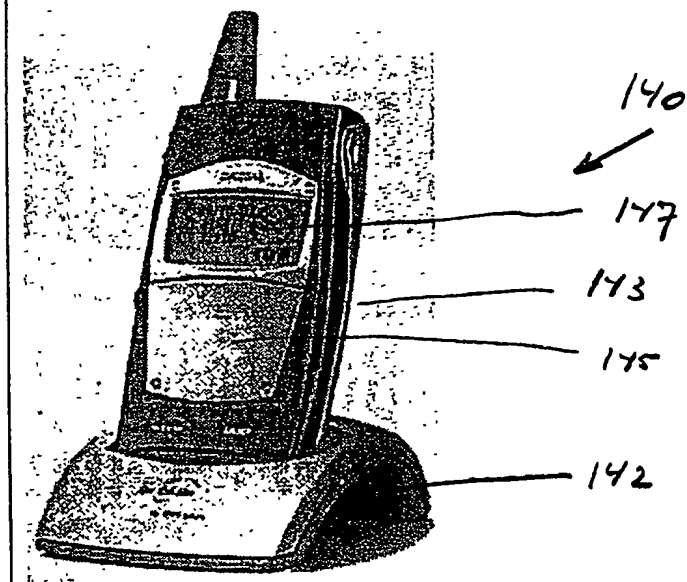


Fig 13

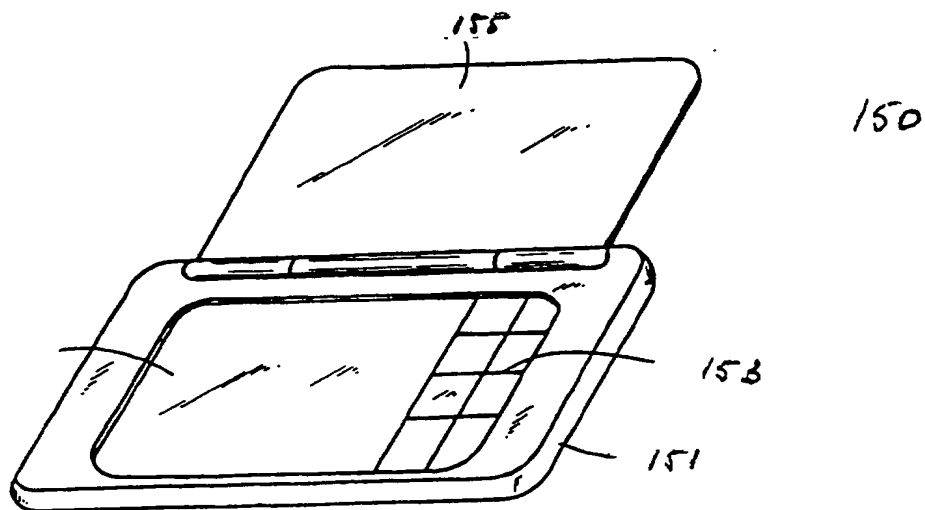


Fig 14



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